ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 29

I-F AMPLIFIER EXPERIMENTS

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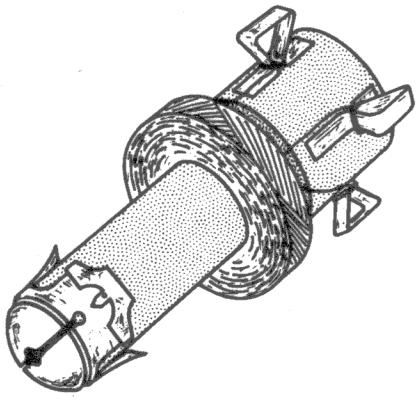
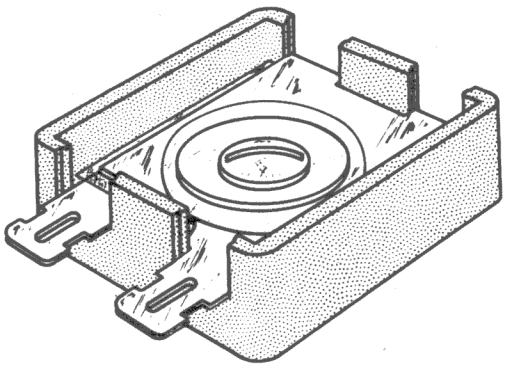


oscillator coil



padder capacitor 100-500 μμf

All the parts in Kit 15 are listed below. Check the parts you receive against this list. Make sure you have the correct quantity of every item. If a part is either missing or defective upon arrival, request a replacement from Department R, Home Study School, RCA Institutes, Inc., 350 West 4th Street, New York 14, N.Y. *Your request must include your name and student number, the complete name and description of the part copied from the Item column below, the Quantity missing or defective, and the reason you are asking for a new part.*

KIT 15

BILL OF MATERIALS

Quantity	Item
1	6SA7 metal electron tube
1	Universal i-f transformer RK 1502
1	Oscillator coil
1	Padder capacitor 100-500 μμf
1	Capacitor 50 μμf, mica
2	Resistor, 82 ohms, ½ watt
2	Resistor, 150 ohms, ½ watt
1	Resistor, 470 ohms, ½ watt
1	Resistor, 680 ohms, ½ watt
1	Resistor, 1,500 ohms, ½ watt

If you get a part slightly different from a part described in this list, the substitute part will not interfere electrically or mechanically with your experiments or equipment.

Experiment Lesson 29

INTRODUCTION

One of the basic principles of the superheterodyne receiver is that the frequency of the signal passing through the intermediate frequency amplifiers is always the same, regardless of the station being received. Because the intermediate-frequency stage need amplify only at this one frequency, it is possible to design the i-f transformers and the i-f amplifier stage for high gain, and almost any desired degree of selectivity. As will be seen in this lesson, the excellent selectivity of the superheterodyne receiver is the result of the selectivity of its i-f transformers. The high gain of the superheterodyne receiver is due primarily to the high gain of the intermediate frequency stage, which is made possible by the superheterodyne principle.

EQUIPMENT NEEDED

Radio receiver chassis

Signal generator

Multimeter

Two i-f transformers, with mounting hardware

One 6BA6 tube

One 7-pin miniature socket, with mounting hardware

One 3-lug terminal strip

4 flashlight cells

One 180-ohm, ½-watt resistor

One 1,000-ohm, ½-watt resistor

One 10 k-ohm, 2-watt resistor

One 3.3 megohm, ½-watt resistor

One 10 megohm, ½-watt resistor

One 270-$\mu\mu$f capacitor

One 0.05-μf capacitor

One 0.1-μf capacitor

One 0.25-μf capacitor

JOB 29-1

To construct an i-f amplifier, and wire the detector circuit for the receiver.

Procedure.

Step 1. Disconnect the following wiring:

a. The lead from lug 1 of TS-C to pin 6 of the 6BA6 tube.

b. The lead from lug 3 of TS-C to TS-D.

c. The jumper wire across TS-D.

d. The lead from the volume control to TS-H.

e. The lead from TS-H to pin 6 of the 6AT6.

Step 2. Disconnect the following components only at the point indicated; leave their other leads connected:

a. The 4,700-ohm resistor at TS-D. Bend this resistor over the r-f tube socket so that it is out of the way.

b. The 10 k-ohm resistor at lug 1 of TS-C.

Step 3. Disconnect and remove the following:

a. The 22 k-ohm resistor across TS-D.

b. The 0.02-μf capacitor from TS-E to ground.

c. The 0.01-μf capacitor from pin 6 of the 6BA6 socket to TS-G.

d. The 470-$\mu\mu$f capacitor from TS-H.

e. The 470 k-ohm resistor from pin 1 of the r-f tube to the chassis.

Step 4. Remove TS-H and TS-D and put them aside.

Step 5. Remove the 2-lug terminal strip TS-J and put a 3-lug terminal strip in its place, as shown in Fig. 29-1. This new terminal strip will still be referred to as TS-J. Make sure it is clearly labelled on your chassis. Rotate it slightly clockwise as shown before tightening it down.

Step 6. Install a 7 pin miniature socket in the location shown in the figure. Use No. 4-36 machine screws and hex nuts and No. 4 lockwashers. Check to see that the blank space between pins 1 and 7 is toward the front of the chassis, as shown in the figure. This socket is for the 6BA6 i-f amplifier tube in the completed receiver.

Step 7. The two i-f transformers that you received are identical. Mount one of these i-f cans in the position of the i-f can marked T_1 in the figure. Draw the leads carefully through the hole in the chassis and fasten the can with No. 6 lockwashers and No. 6-32 hex nuts. Mark the i-f can you have just mounted T_1 by marking the chassis. T_1 will be the i-f *input* transformer in your completed superheterodyne receiver.

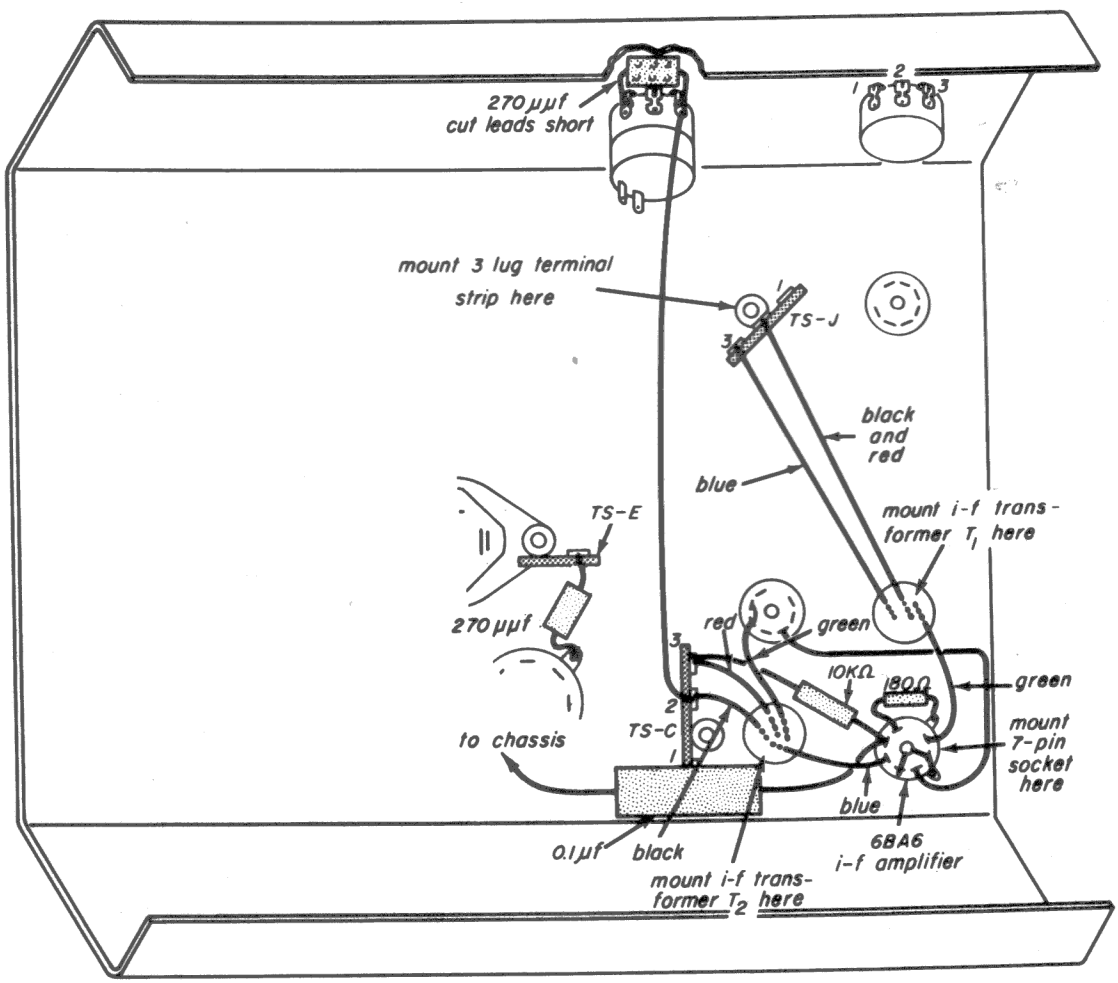


Fig. 29-1

Step 8. Using bare wire, connect pins 2, 4, and the center post on the i-f tube socket to the ground lug near pin 2 on this socket, as shown in the figure. This is a permanent connection.

Step 9. Connect a filament lead between pin 3 of the 6AT6 socket and pin 3 of the i-f tube socket. Run the wire as shown in the figure, and dress it down close to the chassis.

Step 10. Connect a 180-ohm resistor from pin 7 of the i-f tube socket to the ground lug near pin 1 of this socket. This is a permanent connection, so cut the leads to the proper length.

Step 11. Connect the green lead ot the i-f transformer to pin 1 of the tube socket. Cut this lead to the proper length.

Step 12. Connect both the black lead and the red lead to lug 2 (chassis) of TS-J.

Step 13. Connect the blue lead to lug 3 of TS-J.

Step 14. Cut all four leads of the second i-f transformer so that they are 1-3/4 inches long. Strip 1/4 inch of insulation from each lead. Mount the second i-f transformer, using the procedure given in the position shown. It is necessary to remove the screw holding TS-C and remount TS-C over the threaded mounting lug of the i-f transformer. Do this carefully without disconnecting any wiring at TS-C. This transformer will be the i-f *output* transformer in the completed superheterodyne, and will be referred to as T_2. Mark it on your chassis. The connections of all four leads of this transformer are permanent.

Step 15. Connect the blue lead to pin 5 of the i-f tube socket.

Step 16. Connect the red lead to lug 3 of TS-C.

Step 17. Connect the green lead to pins 5 and 6 on the 6AT6 tube socket.

Step 18. Connect the black lead to lug 2 of TS-C.

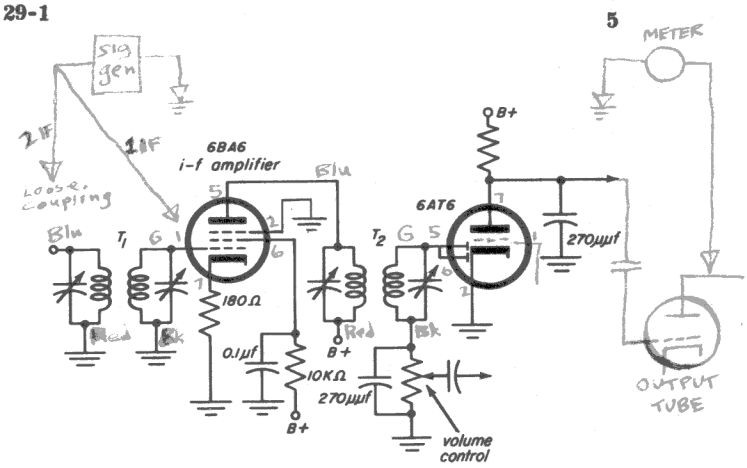


Fig. 29-2

Step 19. Connect a lead from lug 2 of TS-C to terminal 3 of the volume control.

Step 20. Connect the 10 k-ohm 2-watt resistor from lug 3 of TS-C to pin 6 of the i-f tube socket. This is a permanent connection.

Step 21. Connect a 0.1-μf capacitor from pin 6 of the i-f tube socket to a ground lug on the 6X5-GT socket. Use spaghetti to completely insulate the leads of this capacitor.

Step 22. Connect a 270-$\mu\mu$f capacitor across terminals 1 and 3 of the volume control. This is a permanent connection.

Step 23. Connect a 270-$\mu\mu$f capacitor from TS-E to chassis.

The circuit that you have wired is shown in Fig. 29-2. Compare your chassis wiring with this schematic and the wiring diagram of Fig. 29-1, before you proceed.

JOB 29-2

To check the intermediate frequency amplifier stage by means of voltage measurements.

Procedure.

Step 1. Insert a 6BA6 tube into the i-f tube socket.

Step 2. Plug in the receiver and allow the tubes to warm up.

Step 3. Set up the meter to the 500 VDC range.

Step 4. Measure the voltage at the plate and screen grid of the tube and enter them in the Table A.

Step 5. With the meter set to the 5 VDC range, measure the voltage at the cathode of the tube and enter it in the table. Compare your voltages with those given. If there is a discrepancy of much more than 20%, locate the trouble by checking your chassis against the wiring diagram of Fig. 29-1 and the schematic diagram of Fig. 29-2 before you proceed.

Step 6. Disconnect the receiver.

TABLE A – I-F AMPLIFIER

Electrode	Measured Volts	Given volts
Plate 5	235	220
Screen 6	180	170
Cathode 7	3.8	3.5

JOB 29-3

To tune the i-f transformers to resonance at the intermediate frequency, which is 465 kilocycles.* This process is called alignment.

Procedure.

Step 1. Set up the meter to the 15 VAC scale and insert the positive test lead in the output jack.

Step 2. Connect the meter to the plate (pin 3) of the 6K6-GT output tube and chassis.

Step 3. Turn on your signal generator and allow the tubes to warm up. Set the signal generator to band A, 465 kc, and turn the modulation switch on.

Step 4. Connect the signal generator cable to the grid (pin 1) of the 6BA6 i-f tube and the ground clip of the signal generator cable to the chassis.

*The i-f frequency of the completed receiver will be 455 kc. In this experiment 465 kc is used because it is more convenient.

Step 5. Turn on the receiver and allow the tubes to warm up.

Step 6. Turn the volume control to about its mid-position. Adjust the RF ATTEN control of the signal generator to obtain about 4 to 5 volts on the meter.

Step 7. Using an insulated alignment tool, if one is available, or a small screwdriver, adjust the two trimmers at the top of T_2 to obtain maximum deflection on the meter If the deflection goes over 5 volts, reduce the input r-f signal from the generator. Use no more signal input than necessary to obtain a usable deflection of the meter needle. Go back and forth over each adjustment two or three times to make sure that each trimmer capacitor is adjusted for maximum output.

Step 8. Move the signal generator cable to TS-J. Fasten the alligator clip of the hot lead of the signal generator cable around the *insulation* of the blue i-f transformer lead. Connect the ground clip of the cable to lug 2 of TS-J. Repeat Steps 6 and 7 for transformer T_1.

When you have finished the alignment, check it by rotating the main tuning dial on the signal generator for maximum output. If this does not occur at 465 kc, perform Steps 7 and 8 over again more carefully.

Step 9. Turn off the receiver.

EXPERIMENT 29-1

To measure the frequency response of the intermediate-frequency amplifier.

Procedure.

Step 1. Check to see that the meter is set up to the 15 VAC scale and that the positive meter lead is in the OUTPUT jack.

Step 2. Connect the meter to the plate (pin 3) of the 6K6-GT tube.

Step 3. Connect the signal-generator

cable to the grid of the 6BA6 i-f tube and chassis.

Step 4. Turn on the signal generator and allow it to warm up. Check to see that it is set to band A, 465 kc.

Step 5. Turn on the receiver, and allow it to warm up.

Step 6. With the volume control set at about its mid-position, adjust the RF ATTEN control to give about 10 volts output.

Step 7. Tune the signal generator tuning dial carefully for maximum deflection; then readjust the volume control to obtain exactly 10 volts. (If maximum deflection is not obtained at 465 kc, the i-f transformer alignment was not properly performed in the previous experiment.)

Step 8. Adjust the signal-generator pointer to exactly 450 kc. Read the output voltage and enter it in Table B.

TABLE B – SINGLE I-F TRANSFORMER

Frequency	Voltage
450	1.8
457	6.6
465	10
472	4.5
480	1.2

Step 9. Adjust the pointer of the signal generator tuning dial to exactly half-way between the 465 kc mark and the 450 kc mark. This frequency is about 457 kc. Read the output voltage, and enter it in Table B.

Step 10. Move the signal generator pointer an equal distance on the other side of 465 kc. This frequency is about 472 kc. Read the output voltage and enter it in Table B.

Step 11. Estimating as closely as you can, set the pointer the same distance above the 465 kc mark as the 450 mark is below it. This frequency is approximately 480 kc. Read and record the output voltage.

Step 12. Plot a graph of relative response versus frequency on the graph paper provided at the end of this booklet. How does the response curve of the intermediate frequency amplifier compare with the r-f response curve that you plotted in a previous lesson? Which has greater bandwidth? Which has greater selectivity?

Step 13. Move the signal generator cable to TS-J, and fasten the alligator clip to the *insulation* of the blue i-f transformer lead at TS-J.

Step 14. Repeat the response curve measurements according to the directions given in Steps 7 through 11. Enter your results in the Table C.

Step 15. Turn off the receiver.

TABLE C – BOTH I-F TRANSFORMERS

Frequency	Voltage
450	0
457	.5
465	10
472	3.2
480	0

On the same graph paper that you used to plot the response curve for the i-f circuit containing one transformer, plot a curve of relative response versus frequency for the i-f circuit containing two transformers. How does this response curve compare with the previous one? What happens to the selectivity as more tuned circuits are added?

increased

How does the signal get through even

though a direct connection to the blue lead is not made? What is the advantage of coupling the signal into the circuit in this way?

Discussion. The selectivity curves of the intermediate-frequency amplifier show at a glance the excellent selectivity of the intermediate-frequency amplifier and also the contribution of each of the transformers to the over-all selectivity of the circuit.

With both transformers in the circuit, as the frequency is tuned away from the resonant frequency, the response falls off much more rapidly, giving a very narrow bandwidth. This is the reason for the high selectivity of superheterodyne receivers.

By coupling the signal capacitively, as is done by fastening the alligator clip around the insulation of the wire, the loading effect of the signal generator on the tuned circuit is minimized. If this is not done, both the resonant frequency and the Q of the tuned circuit may change considerably. In radio-frequency circuits, coupling a signal into a circuit in this way is termed loose coupling Always use the loosest coupling possible – feed in just enough signal to obtain the necessary meter deflection or other indication.

Typical numerical results for this experiment are shown in Table D, and graphs

TABLE D – RELATIVE RESPONSE		
Frequency	Voltage (volts)	
	One Transformer	Both Transformers
450	3	0
457	5	2.0
465	10	10
472	4	2.0
480	3	0

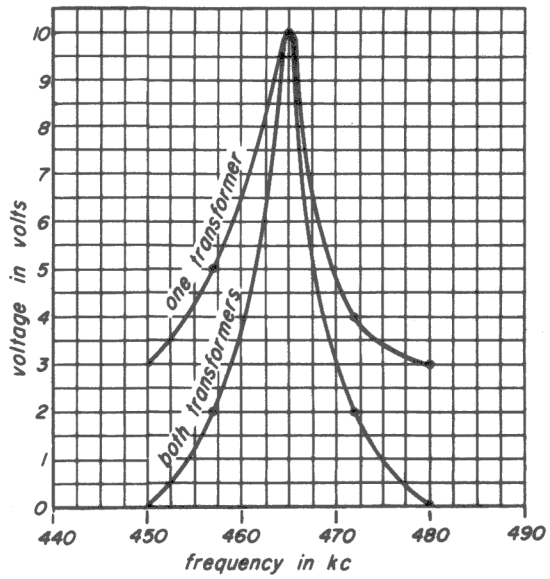


Fig. 29-3

plotted from these results are given in Fig. 29-3. Don't be at all concerned if you don't obtain the same numerical results, as long as the shapes of the resulting curves are similar. The numerical results will probably differ widely because of the close spacing of the frequency scale in this region.

EXPERIMENT 29-2

To study a method of measuring the gain of the intermediate-frequency amplifier.

Information. In this experiment, we will use a method of measuring gain that, in principle, you have already used before. However, because of the high gain of the intermediate-frequency amplifier, and the low voltage of the input signal, the method is a little more indirect.

If both the input signal and the output signal of the intermediate-frequency amplifier could be measured directly, as shown in Fig. 29-4, the gain of the stage would be simply the output voltage divided by the input voltage. The actual voltage input to the i-f stage itself may be about 0.1 volts, and the otuput about 10 volts. We could not measure the input voltage or the output voltage directly, because the signal is too high in frequency to be measured with accuracy by the meter. Therefore, we utilize the amplifica-

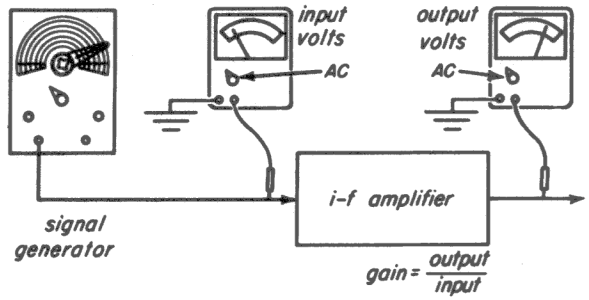


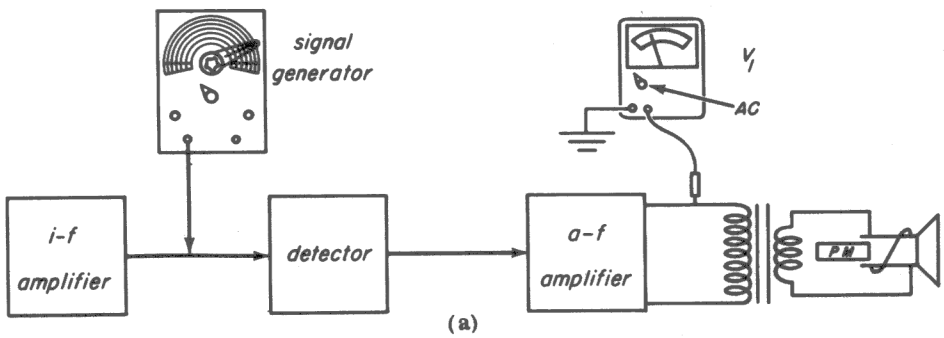
Fig. 29-4

tion of the audio section of the receiver, and make both measurements in this section. By sending the input and the output through an audio voltage amplifier, as shown in Fig. 29-5*a* and *b*, we can amplify both the input and the output by the same proportion.

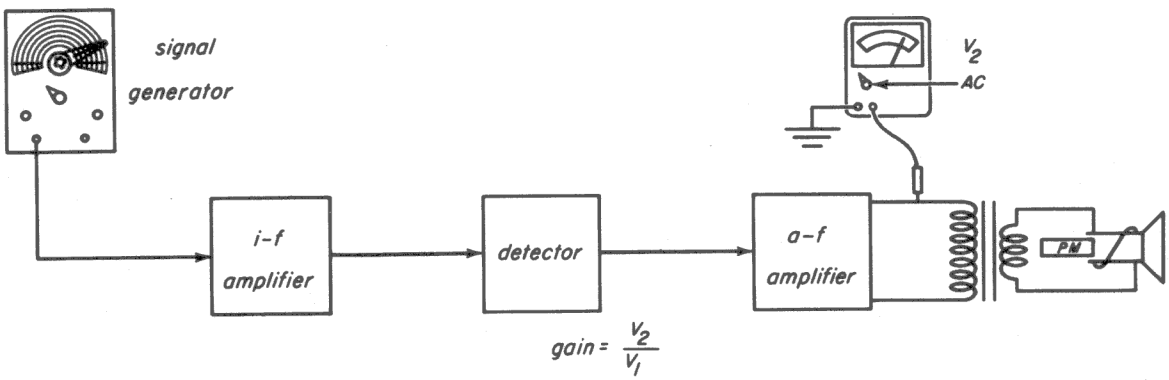
Notice that the output of the signal generator is sent first directly to the plate of the i-f stage and then directly to the grid of the i-f stage. In other words, we are measuring first the signal that has not been amplified by the i-f stage and then the signal that has been amplified by the i-f stage. Let us say that we measure a voltage of 1 volt in the audio section when the signal is applied to the plate of the i-f stage, and a voltage of 100 volts in the audio section when the same signal is applied to the grid of the i-f tube. The *ratio* of the two voltages measured is 100:1. Assuming that all the stages following the i-f amplifier are linear, this ratio of 100:1 is also the ratio of the output of the i-f stage to the input of the i-f stage. Therefore, the gain of the i-f stage is 100.

It should be kept in mind that in using this method, we are depending upon the linearity of all the stages following the i-f amplifier. In order to use this method, care must be taken to see that the operating voltages of these stages and the level of the signal at all points is such that none of these stages are being overloaded.

The danger of overload is critical. As a matter of fact, if you were to follow the method we have just discussed without taking suitable precautions, you would overload the audio stage. If we adjust the input signal from the generator to give 1 volt output in the audio amplifier, the signal generator output is roughly about 0.1 volt. If this signal is now applied to the grid of the i-f amplifier, its output will be 10 volts,



(a)



(b)

Fig. 29-5

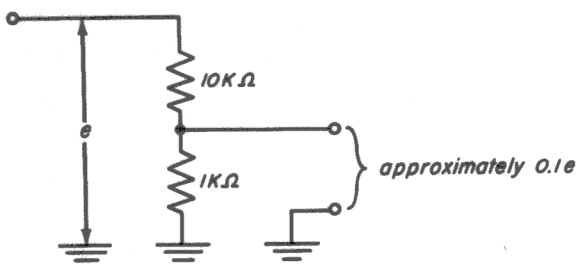


Fig. 29-6

because the gain of the i-f amplifier is 100. But 10 volts of modulated r-f signal, when applied through the detector to the rest of the receiver, will overload the 6AT6 1st audio amplifier.

To prevent overload, the input signal must be reduced. But we have already made the signal so low that it produces only 1 volt after two stages of audio amplification. If we reduce it still more, we will not be able to read the audio voltage accurately.

This difficulty is overcome by reducing the signal a known amount before it is applied to the grid of the i-f amplifier by means of a 10 to 1 voltage divider, as shown in Fig. 29-6. (The voltage ratio is actually 11:1, but 10:1 is close enough for our purposes.) This 10 to 1 reduction is taken into account when we figure the gain. Because of the ratio of the resistors we know what the input signal is without having to measure it, which overcomes the difficulty.

Let's examine how this works out. We connect the output of the signal generator to the plate of the i-f stage and adjust the signal generator so that the voltage output of the audio stage is 1 volt. Then we connect the signal generator to the grid of the i-f tube, *through the 10 to 1 voltage divider.* As a result, the voltage at the grid of the i-f tube is not the same as it was at the plate, but is one-tenth of that voltage. Thus, if it was 0.1 volt at the plate, it is now 0.01 volt at the grid.

Since the gain of the i-f stage is 100, the output voltage of the i-f stage is now 1 volt. This output does not overload succeeding stages.

Now to find the gain of the i-f stage, you take the effect of the voltage divider into account. Let's return for a moment to our first example, in which we assumed that we read an audio voltage of 1 volt when the signal generator was connected to the plate of the i-f stage and a voltage of 100 volts when the signal generator was connected to the grid of the i-f stage. Using the voltage divider arrangement we have described, you would read a voltage of 10 volts instead of a voltage of 100 volts when the signal generator was connected to the grid of the i-f stage. When you computed the gain you would take the voltage divider into account in order to get the actual output voltage, and multiply the 10-volt reading by 10 in order to get the actual gain of the i-f stage.

Procedure.

Step 1. Prepare a voltage divider from a 1,000-ohm and 10 k-ohm resistor, as shown in Fig. 29-7.

Step 2. Connect the free end of the 1,000-ohm resistor to the ground lug near pin 2 on the i-f tube socket. Connect the junction of the two resistors to the grid (pin 1) of the tube, as shown in the figures.

Step 3. Set up the meter to the 15 VAC range, and insert the positive test lead into the OUTPUT jack.

Step 4. Connect the meter to the plate of the audio output tube, and the chassis.

Step 5. Connect the signal generator cable to the plate (pin 5) of the 6BA6 i-f

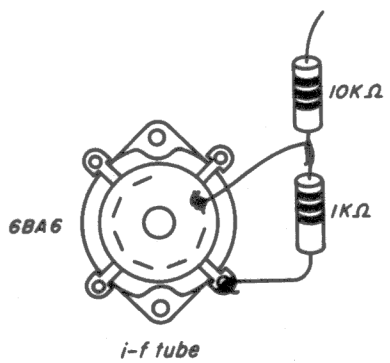


Fig. 29-7

tube. Position the alligator clips carefully so they do not short to other pins or wiring.

Step 6. Set the volume control to its midposition (half-way between its minimum and maximum positions), and set the signal generator RF ATTEN control to minimum.

Step 7. Plug in the signal generator and receiver and allow the tubes to warm up.

Step 8. After the tubes have completely warmed up, adjust the RF ATTEN control to obtain one volt on the meter. Carefully tune the signal generator to obtain maximum deflection, and then readjust the r-f output from the signal generator to obtain exactly one volt on the meter.

Step 9. Turn off the receiver by pulling out the plug – do not disturb the volume control setting. Move the signal generator clip from the plate of the i-f tube to the free end of the 10 k-ohm resistor.

Step 10. Set up the meter to the 75 VAC range.

Step 11. Reinsert the receiver line cord and allow the tubes to warm up.

Step 12. Read and record the voltage indicated on the output meter:

31 volts a.c.

Step 13. Turn off the receiver.

Step 14. Disconnect the voltage divider from the grid, but leave it connected to the ground lug on the tube socket.

Step 15. The gain of the stage is the output voltage multiplied by the voltage-divider ratio. Enter your stage gain here:

310

Discussion. The gain of the intermediate frequency amplifier determined in the manner described above should be roughly 300. This gain figure applies only to a certain input voltage, as determined by the procedure above. If a smaller input signal is used, these measurements will indicate a higher gain, and a larger input signal will give a smaller gain figure.

EXPERIMENT 29-3

To study how the d-c voltage across the volume control varies with the amount of input r-f signal.

Information. You have studied the two basic components needed for an automatic-volume-control system, which are:

1. An amplifier tube whose gain can be controlled by varying its grid bias.

2. A source of d-c voltage that is proportional to the amount of input signal.

In the following experiments you will see how the gain of the 6BA6 i-f amplifier stage varies with the d-c control bias applied to it, and how the d-c voltage across the diode-detector load resistor depends on the amount of input signal. Then you will see how these two effects are combined to produce an automatic-volume-control system giving relatively constant output even with considerable variations in input signal.

Procedure.

Step 1. Set up the meter to the 100 VDC range. Connect the negative meter test lead to terminal 3 of the volume control, and the positive lead to the chassis. (Remember that, in this receiver, the volume control is also the diode-detector load resistor.)

Step 2. Connect the signal generator to the *insulation* of the blue lead of T_1 at lug 3 of TS-J. Check to see that the modulation switch is on.

Step 3. With a crayon or pencil, mark the minimum and maximum positions of the RF ATTEN control. Divide this interval as closely as possible into 5 equal spaces.

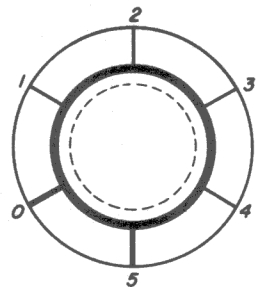


Fig. 29-8

Figure 29-8 may be used as a guide. If desired, this figure can be traced, and the tracing cut out to fit around the RF ATTEN control. These intervals represent approximately equal increases of r-f output, but only at 465 kc.

Step 4. Turn on the receiver and signal generator and allow the tubes to warm up.

Step 5. Adjust the RF ATTEN control of the signal generator to obtain about 20 volts, and tune the signal generator for maximum deflection.

Step 6. Adjust the RF ATTEN control of the signal generator to each of the 5 points marked around it, and read the corresponding d-c voltage across the diode load at each setting. Enter your results in Table E below.

TABLE E	
Relative R-F Input	**D-C Volts**
0	.5
1	5
2	12
3	17
4	23
5	28

Step 7. Adjust the RF ATTEN control to give about 5 volts. Vary the volume control. Does it affect the reading? Why? Then why does the volume change?

No Does not affect output shunts off detector output to gnd.

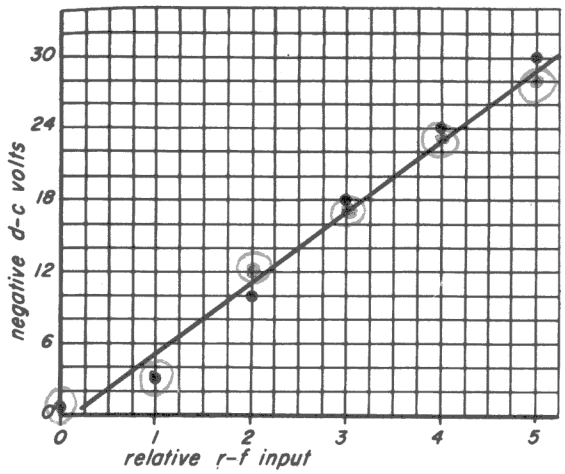


Fig. 29-9

Step 8. Turn off the receiver.

Is the d-c voltage across the diode load proportional to the amount of r-f input? If you wish, you can plot a graph of d-c volts across the diode load against relative r-f response to see the relationship more clearly.

Discussion. Typical results for this experiment are shown in Table F, and plotted in Fig. 29-9. The graph shows that the negative d-c voltage across the diode load resistor is proportional to the amount of r-f signal input. Thus, this negative d-c voltage indicates the relative strength of the signal being received. Therefore, it can be used to control the bias of one or more of

TABLE F	
Relative R-F Input	**D-C Volts**
0	−0.5*
1	−3
2	−10
3	−18
4	−24
5	−30

* The small d-c output with no signal input is due to contact bias, similar to the effect shown in the lesson on Bias Methods.

the preceding amplifiers to maintain a relatively constant output and also to prevent overloading of the i-f amplifiers. These points will be demonstrated in the following experiments.

JOB 29-4

To prepare the chassis for the next experiment.

Procedure.

Step 1. Connect together 4 flashlight cells in series to make a 6-volt battery.

Step 2. Connect the negative lead of this 6-volt battery to terminal 3 of the unused potentiometer (the former "regeneration control") mounted on the chassis. Connect the positive lead to terminal 1 of the potentiometer. This potentiometer will now be referred to as the *bias control.*

Step 3. Connect a wire between terminal 1 of this potentiometer and any convenient chassis point.

Step 4. Connect a wire between terminal 2 (center tap) of the potentiometer and lug 1 of TS-J.

Step 5. Disconnect the black lead of T_1 from lug 2 of TS-J and connect it to lug 1 of this terminal strip.

Step 6. Connect a 470-$\mu\mu$f capacitor across lugs 1 and 2 of TS-J.

Step 7. Reconnect the junction of the 10:1 voltage divider to the grid of the i-f tube.

Step 8. Check your wiring by measuring the d-c voltage at the grid (pin 1) of the 6BA6 i-f tube. By turning the bias control it should be possible to vary the grid voltage from 0 to about −6 volts. When you have finished checking, set the bias control for zero voltage.

EXPERIMENT 29-4

To see how the gain of an intermediate frequency amplifier using a remote cutoff tube varies as the d-c bias is changed.

Step 1. Connect the signal generator to the plate (pin 5) of the 6BA6 tube. Check to see that it is tuned to 465 kc. Position the alligator clips carefully so that they cannot short.

Step 2. Turn on the signal generator and receiver, and allow the tubes to warm up.

Step 3. Set the volume control to its mid-position.

Step 4. Set up the meter to the 25 VDC range, and measure the total bias on the tube by connecting the negative meter lead to the grid and the positive meter lead to the cathode. (Check that the bias control is fully counterclockwise.)

Enter the reading in the first space in the table.

Step 5. Set up the meter to the 15 VAC range, and insert the positive lead in the OUTPUT jack. Connect the *positive* test prod to the plate, of the 6K6-GT output tube, and the *negative* test prod to the chassis.

Step 6. Adjust the RF ATTEN control to obtain exactly 1 volt on the output meter. Check to see that the signal generator is adjusted for maximum deflection and readjust to obtain 1 volt.

Do not disturb the RF ATTEN or volume control setting until the experiment is completed.

Step 7. Change the meter over to the 75 VAC range.

Step 8. Connect the signal generator to the grid (pin 1) of the i-f tube through the 10:1 voltage divider.

Step 9. Measure the voltage at the plate of the output tube. This voltage should be about the same as the one obtained in Experiment 29-2, and this voltage multiplied by 10 represents the gain of the stage. Enter it

next to the corresponding bias in Table G below.

Step 10. Remove the meter test prod from the plate. Set the function switch to d-c, and transfer the positive lead from the OUTPUT jack to the positive jack.

Step 11. Connect the meter to read the bias on the tube by connecting the positive lead to the cathode and the negative lead to the grid.

Step 12. Adjust the bias control to give a total bias of −3.5 volts as called for in the table.

Step 13. Change over the meter to an output meter by putting the positive lead in the OUTPUT jack, and set the function switch to AC. Read the new output voltage. Multiply by 10 to get the gain, and enter it alongside the corresponding bias in the table.

Step 14. Change over the meter to read d.c. as in Step 10, and adjust the bias control to obtain the next bias total voltage called for in Table G.

Step 15. Measure the gain at this new bias voltage, and continue in this way until you have filled out the table completely.

Step 16. Turn off the receiver.

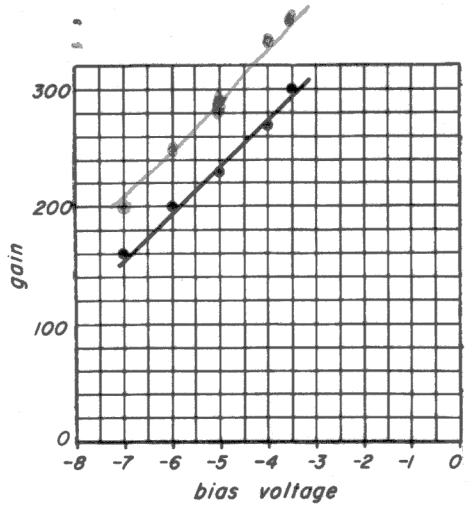


Fig. 29-10

What happens to the gain as the bias is made more negative? If you wish, plot a graph of gain against bias voltage on the graph paper provided in order to see this relationship more clearly.

Discussion. Because of the supercontrol or variable mu tube used as the intermediate frequency amplifier, considerable variation in gain may be obtained by varying the d-c bias on the grid. The gain may be controlled from about 300 times at the minimum required bias of approximately −3.5 volts, to about 150 times at the bias of −7 volts.

Typical results for this experiment are shown in Table H, and the results of this table are plotted as in Fig. 29-10.

TABLE G – I-F AMPLIFIER GAIN VARIATION	
Bias, (volts)	**Gain**
−3.5 -3.5	360
−4.0	340
−5.0	290
−6.0	250
−7.0	200

TABLE H – I-F AMPLIFIER GAIN VARIATION	
Bias (volts)	**Gain**
−3.5	300
−4.0	270
−5.0	230
−6.0	200
−7.0	160

JOB 29-5

To prepare the chassis for the following experiments.

Procedure.

Step 1. Disconnect and put aside the 10:1 voltage divider.

Step 2. Disconnect the batteries from the bias control.

Step 3. Disconnect the lead from the control to lug 1 of TS-J.

Step 4. Disconnect and put aside the 470-$\mu\mu$f capacitor from TS-J.

Step 5. Reconnect the black lead of T_1 to lug 2 of TS-J.

Step 6. Connect a 3.3-megohm resistor across lugs 1 and 2 of TS-C.

Step 7. Connect a 0.05-μf capacitor from lug 1 of TS-C to a ground lug on the 6X5-GT socket. Be sure that the lead connected to the outside foil of the capacitor is connected to the chassis.

EXPERIMENT 29-5

1. To measure the variation in audio output without automatic volume control.

2. To note the susceptibility of the i-f amplifier to overload without automatic volume control.

Procedure.

Step 1. Set up the meter to the 75 VAC scale, and using the output meter connection, connect it to the plate (pin 3) of the output tube.

Step 2. Adjust the RF ATTEN control on the signal generator to position 3 on the calibrated scale around it and connect the signal generator cable around the insulation of the blue lead near TS-J. Turn the modulation control on.

Step 3. Turn on the signal generator and receiver and allow the tubes to warm up.

Step 4. Adjust the volume control to give 30 volts output. Retune the signal generator for maximum deflection and readjust for exactly 30-volts output.

Step 5. Reduce the input signal by moving the RF ATTEN control to position 1. Read the output voltage and enter it in the table below.

TABLE I – AUDIO OUTPUT VARIATION WITHOUT AVC

R-F Input	Audio Output (volts)
1	9
3	30
5	51

Step 6. Increase the r-f input by adjusting the RF ATTEN control to position 5. Read the output voltage and enter it in the table. The table now shows the increase and decrease in audio output without AVC produced by an increase and decrease in input signal above a certain reference level. This will be compared later with the change in audio output produced with AVC by an equal change in input signal. The comparison can be made by examining the tables. If desired, the results can be plotted on the graph paper provided to more clearly show the relationship.

Step 7. Connect the signal generator cable directly to lug 3 of TS-J.

Step 8. With the RF ATTEN at point 3, adjust the volume control to give about 30 volts. Retune the signal generator for maximum deflection and readjust to 30 volts, if necessary.

Step 9. Now rotate the RF ATTEN control slowly from its minimum to maximum

setting while watching the meter. If the output voltage rises and then falls, it indicates that overloading is taking place in the i-f amplifier.

What happens to the meter reading?

went up.

Is overloading taking place as the input signal is increased?

no

Step 10. Turn off the receiver.

EXPERIMENT 29-6

1. To measure the variation in audio output with automatic gain control.

2. To note the susceptibility of the i-f amplifier to overloading with AVC.

Procedure.

Step 1. Disconnect the black lead of T_1 from lug 2 of TS-J, and connect it to lug 1 of TS-C.

Step 2. Set up the meter to the 75 VAC scale, and using the output meter connection, connect it to the plate (pin 3) of the output tube.

Step 3. Adjust the RF ATTEN control on the signal generator to position 3 on the calibrated scale around it and connect the signal generator cable around the insulation of the blue lead near TS-J. Check that the modulation control is on.

Step 4. Turn on the signal generator and receiver and allow the tubes to warm up.

Step 5. Adjust the volume control to give 30 volts output. Retune the signal generator for maximum deflection and readjust for exactly 30 volts output.

Step 6. Reduce the input signal by moving the RF ATTEN control to position 1. Read the output voltage and enter it in the table.

TABLE J – AUDIO VARIATION WITH AVC

R-F Input	Audio Output (volts)
1	13
3	30
5	41

Step 7. Increase the r-f input by adjusting the RF ATTEN control to position 5. Read the output voltage and enter it in the table. The table now shows the increase and decrease in audio output with avc, produced by an increase and decrease in input signal above a certain reference level. Compare the results of this and the previous experiment by examining the tables. If desired, the results can be plotted on the graph paper provided to more clearly show the relationship.

Step 8. Connect the signal generator cable directly to lug 3 of TS-J.

Step 9. With the RF ATTEN at point 3, tune the signal generator for maximum deflection and adjust the volume control to give about 30 volts.

Step 10. Now rotate the RF ATTEN control slowly from its minimum to maximum setting. If the output voltage rises and then falls, it indicates that overloading is taking place in the i-f amplifier.

What happens to the meter reading?

rises steadily

Is overloading taking place as the input signal is increased?

no

What is the effect of avc on overloading in the i-f amplifier?

Step 11. Turn off the receiver.

Discussion.

The effect of automatic volume control in maintaining a more constant output volume can be seen from Table K, which contains typical experimental results for the last two experiments.

These results are also plotted in Fig. 29-11.

Even with AVC added to the i-f amplifier, these results show that the output still changes quite a bit when the input signal is varied. However, it must be remembered that in this case, the AVC voltage is applied to only one tube, whereas in the completed receiver the AVC voltage will be applied to three tubes. Thus the AVC voltage has greater effect in maintaining a more constant output in the completed receiver.

TABLE K – AUDIO-OUTPUT VARIATION

Relative R-F Input	Output	
	Without AVC (volts)	With AVC (volts)
1	7	12
3	30	30
5	50	42

Your experiments should also show that overload may take place without AVC but does not take place when the stage is AVC controlled.

EXPERIMENT 29-7

To study the effect of varying the time constant of the AVC filter on the operation of the receiver.

Procedure.

Step 1. Unsolder the ground connection of the 0.05-μf capacitor at lug 1 of TS-C.

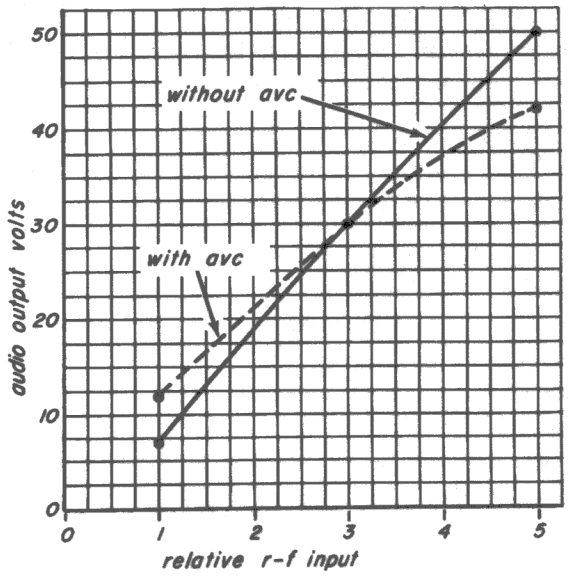


Fig. 29-11

Connect this free lead of the capacitor back to chassis, using your clip lead.

Step 2. Set up the meter to the 5 VDC scale, and put the positive lead into the positive jack.

Step 3. Connect the meter to lug 3 of the volume control and chassis.

Step 4. Connect the signal-generator cable clip around the insulation of the blue lead, near TS-J. Connect the ground clip to the chassis.

Step 5. Turn on the receiver and signal generator and allow them to warm up.

Step 6. Turn the volume control to its midposition, and adjust the r-f output from the signal generator to obtain about half-scale deflection.

Step 7. Disconnect the AVC filter capacitor from the chassis by disconnecting the clip lead. What happens to the meter reading? What happens to the audio output? Judging from the meter reading, is the r-f signal reaching the detector changed? Why does the audio output change? What is the disadvantage of too low an AVC time constant?

Step 8. Disconnect the receiver, and resolder the capacitor.

Step 9. Set up the meter as an output meter on the 75 VAC scale and connect it to the plate of the audio output tube.

Step 10. Turn on the receiver. With the volume control set to its midposition, adjust the r-f output for half-scale deflection.

Step 11. Test the relative response time of the normal AVC circuit. Short out the r-f input by putting a screwdriver from the hot lead of the signal generator to chassis. Now, watch the output meter as the short is removed. Estimate the number of seconds it takes for the output voltage reading to stabilize itself.

not even 1
seconds

Step 12. Turn off the receiver.

Step 13. Disconnect the black lead of T_1 from lug 1 of TS-C. Connect one end of a 10-megohm resistor to lug 1 of TS-C. Connect the black lead of T_1 to the other end of this resistor. (This temporary connection must be self supporting, as there is no convenient terminal lug for it.)

Step 14. Connect one lead of a 0.25-μf capacitor to the junction of the black lead and the 10-megohm resistor, and the other lead of the capacitor to any convenient chassis point.

Step 15. Turn on the receiver and allow the tubes to warm up. With the volume control set at its midposition, adjust the r-f output for half-scale deflection.

Step 16. Test the response time of the avc filter consisting of the 10-megohm resistor and 0.25-μf capacitor as in Step 10. Ground the hot side of the signal generator to the chassis with a screwdriver. Watch the output meter as the ground is removed. Count and record the number of seconds it takes for the output voltage to stabilize itself.

7
seconds

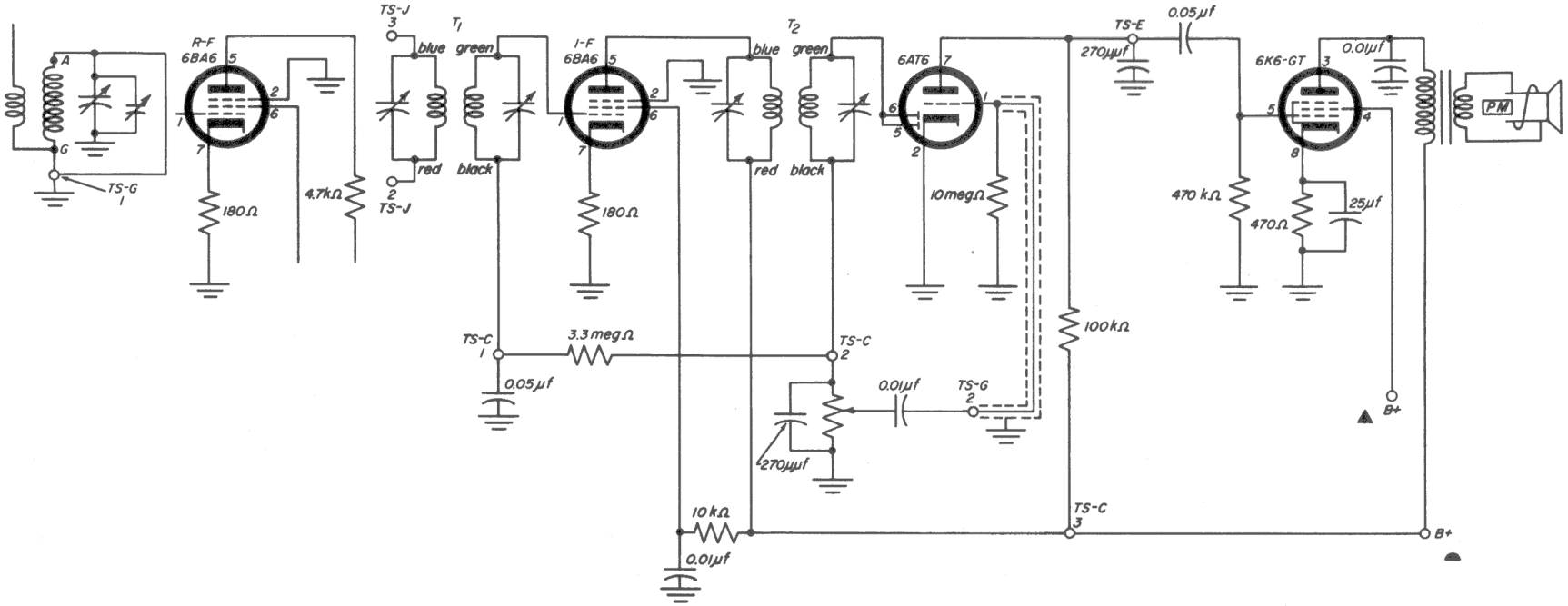
How does the response time of the high-time-constant filter compare with that of the normal filter? What is the result of too high a time constant in the AVC filter?

Step 17. Turn off the receiver.

Step 18. Remove the 0.25-μf capacitor and the 10-megohm resistor, and reconnect the black lead of T_1 to lug 1 of TS-C. A schematic diagram of the condition of the chassis appears at the end of the lesson.

Discussion. The results of this experiment show that reducing the AVC time constant causes a decrease in the audio output volume. This is because the reduced AVC filtering allows audio voltages to exist on the AVC line. The waveform of the audio voltages is identical to the envelope of the modulated wave. But the audio voltages increase and decrease in opposition to the increases and decreases of the modulated envelope. The most positive peak of the modulated envelope, representing the greatest amount of i-f input to the detector, results in the most negative peak of the demodulated audio output. When the audio output signal is allowed to be on the AVC line, it biases the tubes more negative at the instant the i-f output tries to be maximum. Increasing the bias at this instant causes a reduction in gain at the same instant the i-f output tries to be maximum. This reduces the amplitude of the variations in the envelope of the i-f carrier.

In this circuit, the actual response time of the AVC circuit cannot be measured, since the meter needle also takes considerable time to respond. Therefore, only the relative response time of the AVC circuit under the two conditions can be examined. The experiment shows that the relative response time of the AVC circuit is changed from a second or less with the normal time constant to several seconds when the time constant is made too high, Thus, the time constant should be made as high as possible so as not to reduce the audio output. But if the time constant is made too high, the AVC circuit will take too long to respond to fluctuations in input signal, such as those caused by fading.



Condition of Radio Receiver Chassis at End of Experiment Lesson 29